WHITE PAPER

The Business Case for Using a Common Multi-haul DWDM Platform in a Metro/Long-Haul Network

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Network Strategy Partners, LLC (NSP)

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Executive Summary

New network services such as Internet, residential video, business Carrier Ethernet, and broadband wireless are driving growth in demand for DWDM fiber transport services. Currently there are 1.5 Billion Internet users world-wide and it is expected that Internet traffic will double every two years[1]. Also transport capacity will increase in the future from 10G and 40G to 100G. As a result, demand for transport services is more unpredictable, and the lines between metro and long-haul demand are becoming fuzzy. Traditionally, service providers built separate metro and long-haul DWDM networks using different products and potentially different vendors. Metro products are often cost-optimized for shorter distances, supporting 2.5G and 10G transport with 40 channels of capacity. Long-haul DWDM systems are typically optimized for longer distances, 10G and 40G transport, and up to 80 channels.

In order to address this disconnect in DWDM network architecture, Nokia Siemens Networks developed the SURPASS hiT7300, a multi-reach DWDM platform that is optimized for metro, regional, and long-haul networks. The multi-reach architecture allows transport services to be provisioned between end-points based on service demand—not arbitrary borders between metro, regional, and long-haul DWDM networks. By allowing transport services to extend from metro DWDM to core DWDM networks without optical-electrical-optical (OEO) conversion, it is possible to reduce the number of transponders required between metro and long-haul network interfaces. Additionally, operations expenses are reduced by eliminating the need for separate metro and long-haul systems.

The SURPASS hiT7300 is performance and cost optimized for classically separated metro and long-haul networks and is used by service provider in both metro and long-haul networks. However, the focus of this paper is on the cost benefits of using the SURPASS hiT7300 in multi-haul combined metro and long haul networks. A detailed total cost of ownership (TCO) model is used to analyze the CapEx and OpEx savings of a SURPASS hiT7300 multi-reach network. The model compares two alternative architectures:

- Combined metro and long-haul DWDM network using the SURPASS hiT7300
- Separate DWDM metro and long-haul networks using products from market-leading vendors

The hiT7300 combined metro and long-haul DWDM solution results in a five year cumulative savings of 38% over the alternative solution (see Figure 1 for a TCO summary). The CapEx savings is primarily due to 1) eliminating the need for two DWDM systems for metro and long-haul and 2) reductions in transponders required for OEO conversion at the metro-core network interface. The hiT7300 solution also achieves significant OpEx savings:

- Engineering, facilities, and installation expenses are reduced
- Test and Certification expenses are reduced
- Training expenses are reduced by using a single DWDM product for metro and long-haul networks
- Vendor service contracts are reduced as a direct result of CapEx reductions
- The cost of sparing is lower

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[1] See http://www.internetworldstats.com/stats.htm.

- Environmental expenses are reduced (power, cooling, and floor space)

The SURPASS hiT7300 also improves time to revenue or service activation by reducing truck rolls required to core nodes when provisioning metro to long-haul links. Truck rolls are reduced because transponders do not need to be installed at the metro-core network boundaries. The body of this paper presents a logical framework for the multi-reach network business case, as well as the detailed assumptions, analysis, and results underlying the TCO analysis.

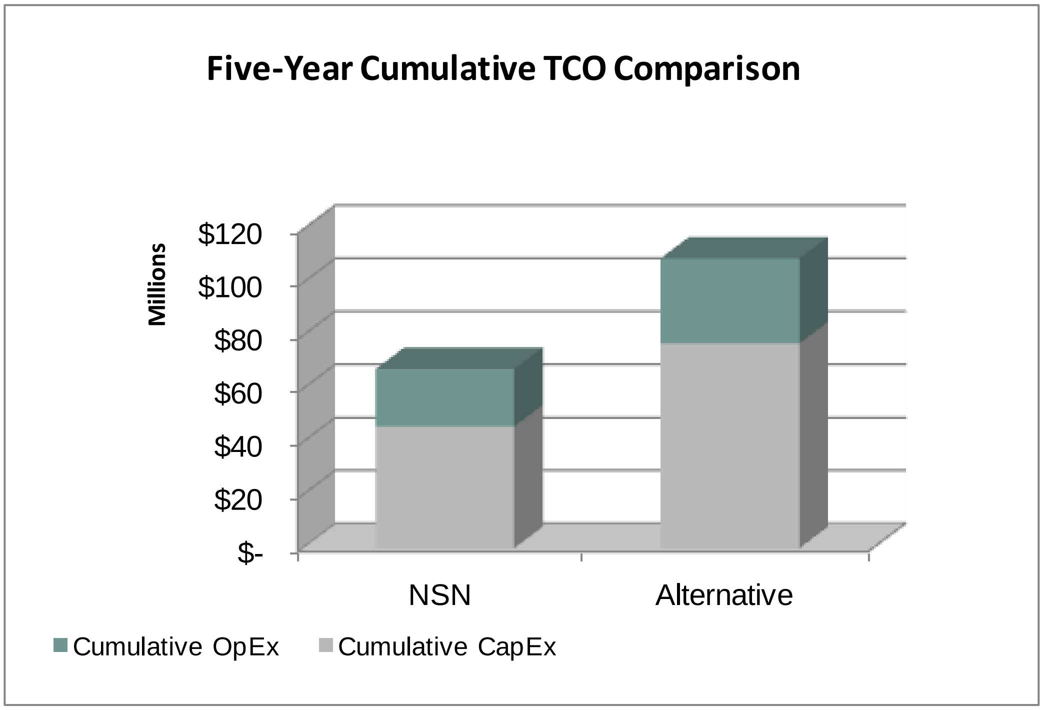


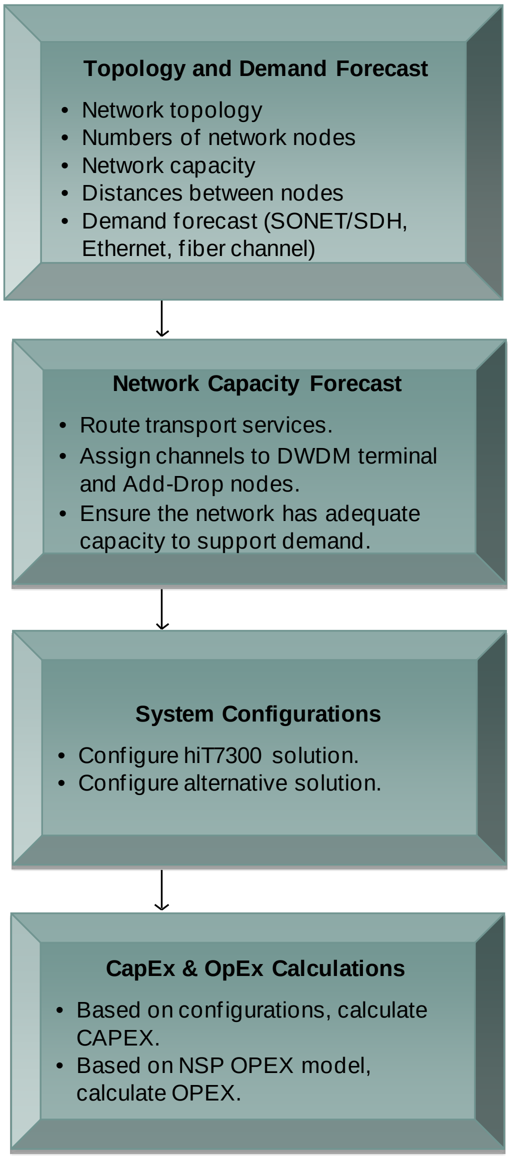
Figure 1. Five-Year Cumulative TCO Comparison

Introduction

This paper makes the business case for building a multi-reach metro/long-haul DWDM network using the SURPASS hiT7300. A detailed TCO model created by Network Strategy Partners compares two alternative DWDM system architectures:

1. Combined metro/long-haul DWDM network using the SURPASS hiT7300
2. Separate DWDM metro and long-haul networks using products from market leading vendors

The TCO model framework is presented in Figure 2. Network assumptions regarding service demand, network topology, numbers of nodes, network capacity, and distances between central offices are input to the model. Based on demand, network topology, and the network design logic, the model calculates DWDM system configurations and the resulting CapEx and OpEx expenses. Detailed configurations are created that include chassis and common equipment, amplifiers, wavelength selectable switches (WSS), dispersion compensation units (DCU), and transponder/muxponders. These detailed equipment configurations are used to calculate both CapEx and OpEx. Multiple categories of OpEx are discussed later in this paper.



Topology and Demand Forecast

- Network topology
- Numbers of network nodes
- Network capacity
- Distances between nodes
- Demand forecast (SONET/SDH, Ethernet, fiber channel)

Network Capacity Forecast

- Route transport services.
- Assign channels to DWDM terminal and Add-Drop nodes.
- Ensure the network has adequate capacity to support demand.

System Configurations

- Configure hiT7300 solution.
- Configure alternative solution.

CapEx & OpEx Calculations

- Based on configurations, calculate CAPEX.
- Based on NSP OPEX model, calculate OPEX.

Figure 2. TCO Model Framework

NSP's approach to estimating CapEx and OpEx utilizes a blend of practical experience[2] in helping service providers design and operate networks together with best practice models promulgated by standards organizations. CapEx estimates are made by pricing out systems designs using system vendors' data sheets and manufacturers' price lists where publicly available. OpEx is estimated through a similar bottom-up estimate of hours and materials required to operate the network. NEBS (Network Equipment-Building Specification managed by Telcordia) guidelines are used to estimate environmental costs, while the ISO/OSI Network Management Model (ITU-T X.700) is used to structure the analysis of OpEx items such as capacity management, provisioning, surveillance, monitoring, data collection, maintenance, and fault isolation. Labor rates are typical for large U.S. service providers.

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[2] See the "Experience" tab at www.nspllc.com for a detailed listing of NSP's work for service providers, systems vendors, and enterprises.

The following sections of this paper present an overview of the assumptions used in our model and a summary of the results.

Key Assumptions

The key assumptions for network topology, architecture, and service demand are presented in the following sections.

Topology Assumptions

The TCO model uses the hypothetical DWDM transport network used in this analysis, consisting of eight metro networks interconnected by a core long-haul network. The topology of each metro network has a four-level hierarchy (see Figure 3):

- Spur nodes at the edge of the network
- Aggregation nodes interconnected in an aggregation ring
- Hub nodes connecting aggregation rings in a hub ring
- Core nodes connecting hub rings to the long-haul network

For each aggregation ring there are four aggregation nodes and two spur nodes. There are three hub nodes interconnecting with the aggregation rings and the core node. Each core node connects to the long-haul network using three fiber links in a mesh architecture.

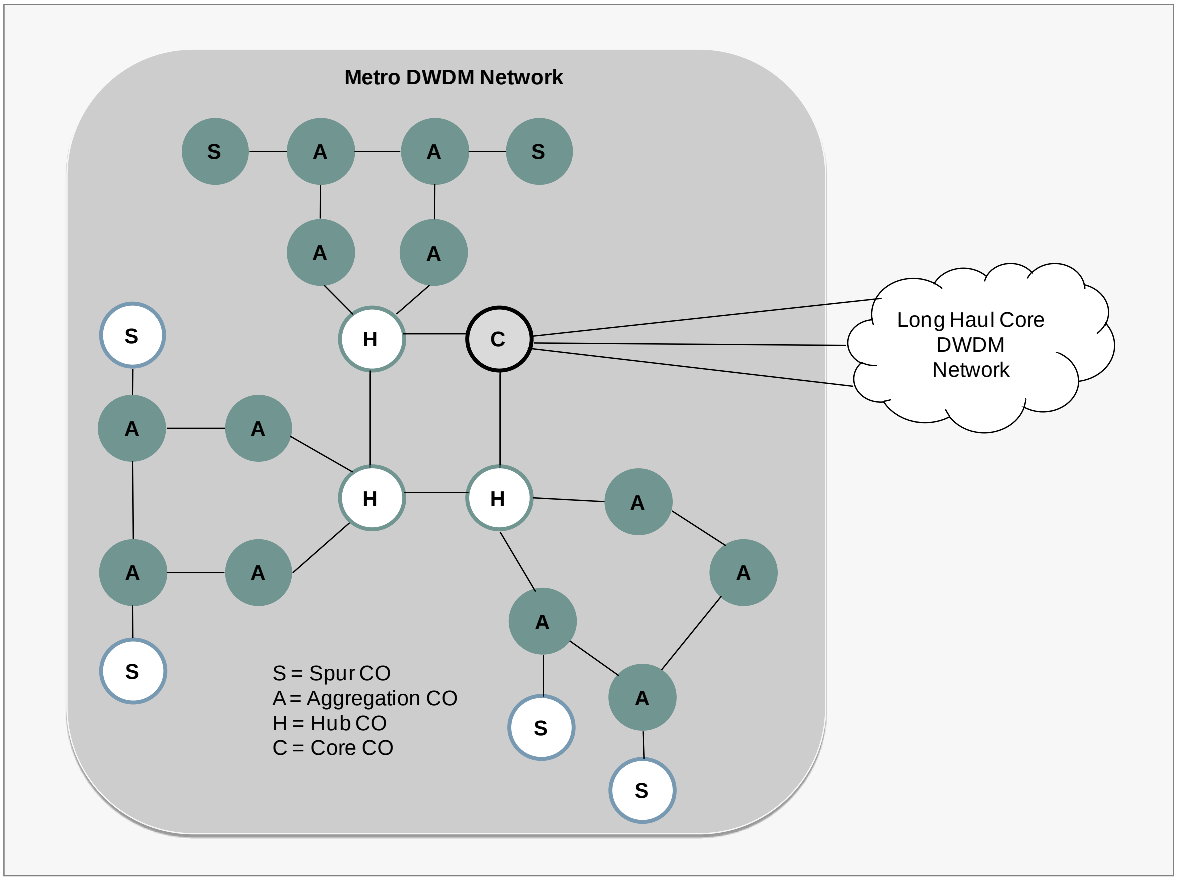

Figure 3. Network Topology

DWDM System Architecture Assumptions

The configuration of the spur nodes, aggregation nodes, and hub nodes are identical for the two architectural alternatives and is depicted in Figure 4. The spur node is configured as a DWDM terminal with multiple transponders and muxponders to provide transport services. Aggregation nodes are connected together in aggregation rings. There are two types of aggregation nodes: those connected to spurs and those not connected to a spur. The former are configured as 3-degree ROADMs, and the latter are configured as 2-degree ROADMs. Both aggregation nodes use transponders and muxponders for transport services. Aggregation rings are connected to hub nodes that are interconnected in a hub ring. Hub nodes connect to both the hub ring and aggregation ring and therefore use a 4-degree ROADM configuration. Hub nodes also provide services using transponders and muxponders. Since the configuration of the spur, aggregation, and hub nodes for both architectural alternatives is identical, equipment pricing is assumed to be identical for each solution.

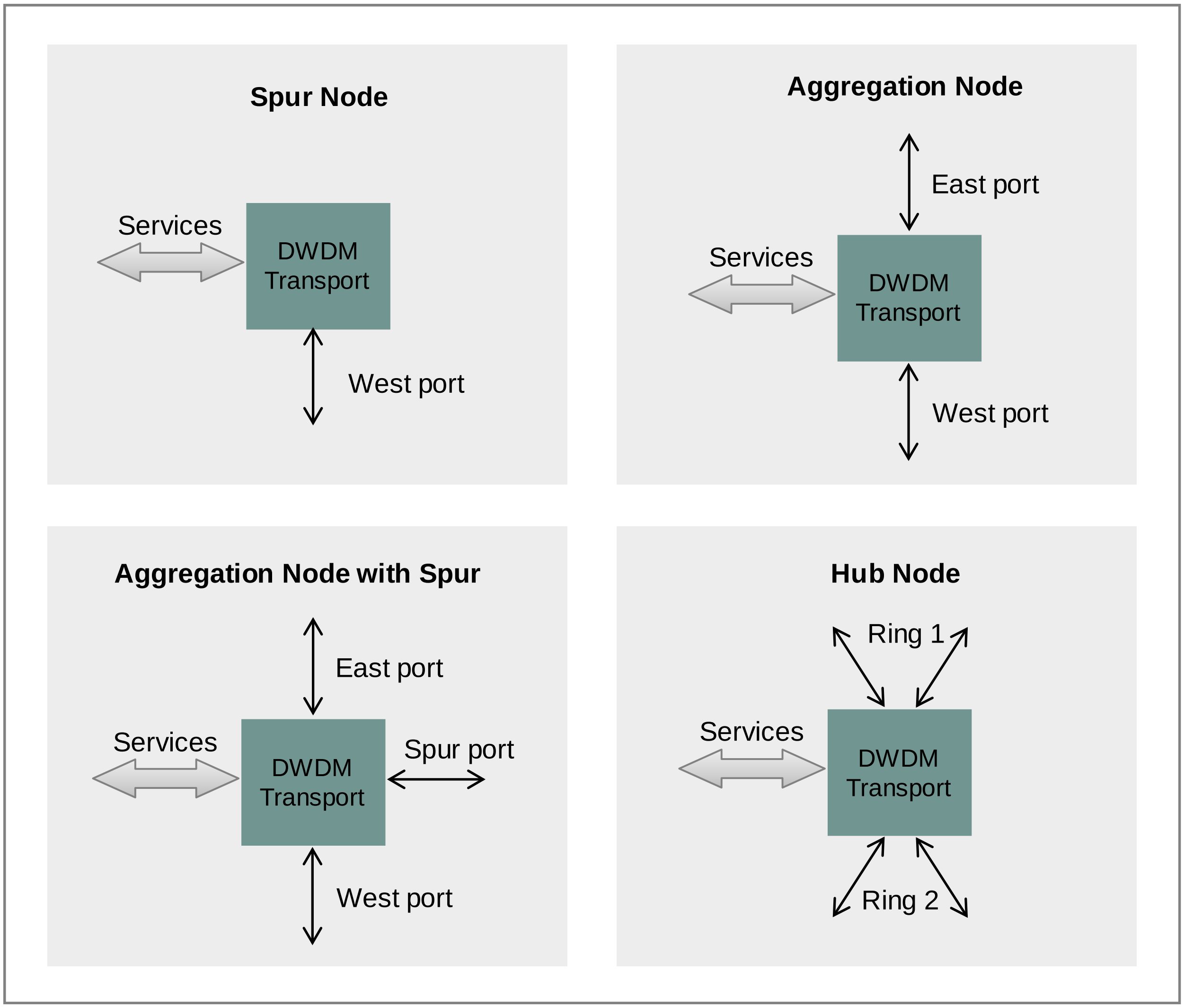

Figure 4. Configuration of Spur Nodes, Aggregation Nodes, and Hub Nodes

The TCO difference between the two architectural alternatives is found in the core node configurations shown in Figure 5. In the Nokia Siemens Networks solution, a single 5-degree DWDM node is used to connect to the hub ring and to three long-haul mesh links. The Nokia Siemens Networks architecture does not require signal regeneration between the metro and core networks unless distance limitations dictate the need for regenerators. In the alternative architecture, two systems are used: (1) a metro DWDM system connecting to the metro hub ring and (2) a long-haul system connecting to the long-haul mesh network. All transport services between the metro and long-haul nodes must be regenerated between the two systems using transponders and muxponders.

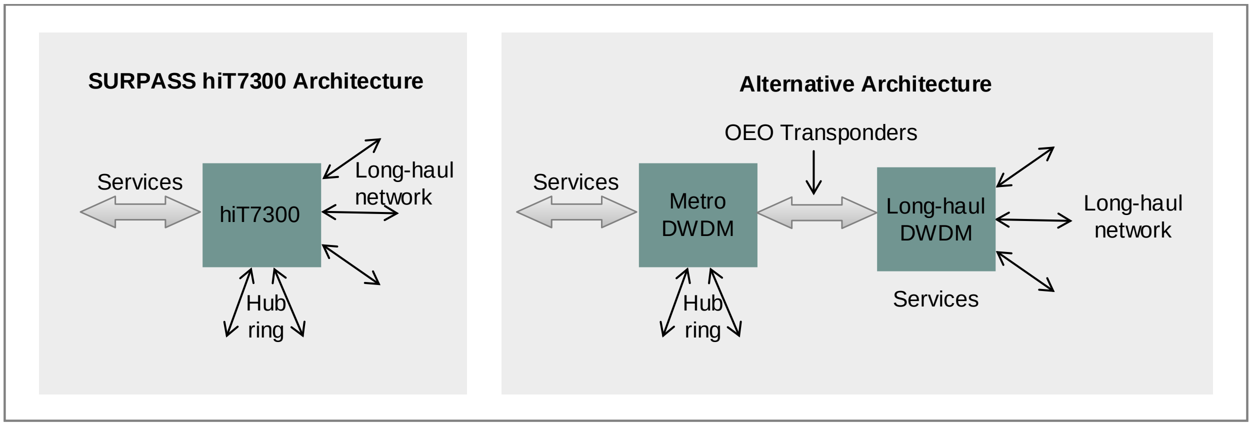

Figure 5. Core Node Architecture

Service Demand Assumptions

The TCO model configures network equipment based on the network topology, architecture assumptions, and demand requirements. Our demand model assumes there are three fundamental types of services:

1. SONET/SDH overlay networks (unprotected on the DWDM network)
2. Point-to-point unprotected channels of varying capacity
3. Point-to-point protected channels of varying capacity

In the spur and aggregation rings, we assume there is one OC-48/STM-16 SONET/SDH overlay network. In the hub ring, we assume there is one OC-48/STM-16 and one OC-192/STM-64 SONET/SDH overlay network running over the DWDM network. Each overlay network uses two transponders at each node but only one channel over the ring. This is because the SONET/SDH ADMs are connected in an overlay ring on top of the DWDM ring. The SONET/SDH rings provide protection, and therefore no protection is required in the DWDM rings.

In addition to the SONET/SDH overlay rings, we assume a combination of point-to-point protected and unprotected demand consisting of the following:

- SONET/SDH (OC-48/STM-16, OC-192/STM-64, OC-768/STM-256)
- Ethernet (1 GbE and 10 GbE)
- Fiber channel (1 Gbps, 2 Gbps, and 4 Gbps)

Unprotected circuits use a single channel to traverse the network, while protected circuits use a diverse channel to traverse the ring in opposite directions. The distribution of service demand is presented in Figure 6, and the distribution of local metro vs. metro-to-core traffic is depicted in Figure 7. We assume that most of the circuits are local to the metro network, while a small percentage of circuits traverse from the metro to the core network[3].

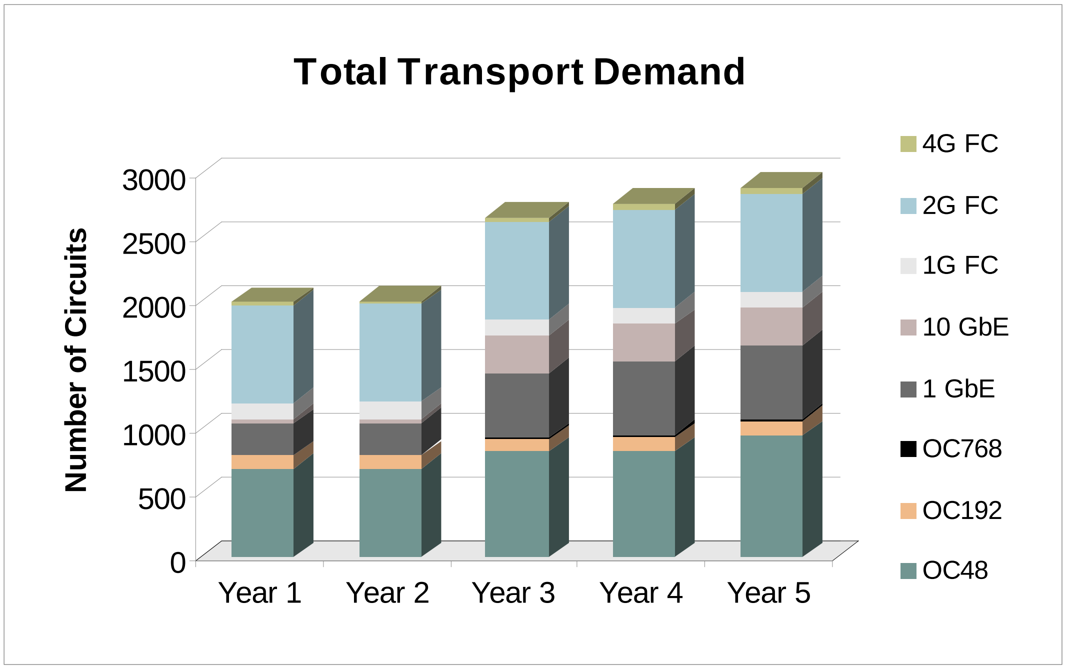

Figure 6. Distribution of Service Demand

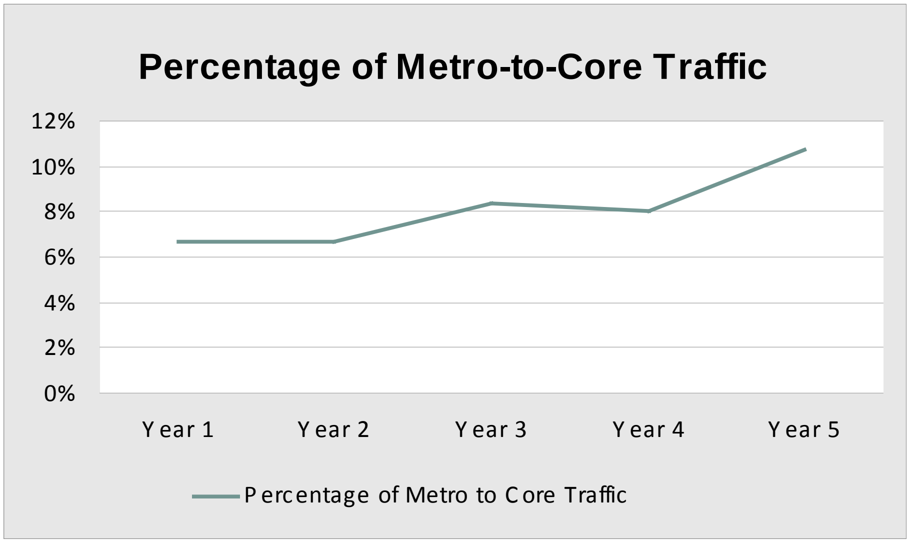

Figure 7. Distribution of Local Metro vs. Metro-to-Core Traffic

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[3] This is a conservative assumption. If the percentage of metro-to-core circuits increases, then the value proposition for the NSN hiT7300 solution becomes even stronger.

Miscellaneous Assumptions

In addition to the network topology, configuration, and service demand assumptions, our model also uses some miscellaneous assumptions presented in Table 1.

Table 1. TCO Model Miscellaneous Assumptions

Parameter Description	Value
Metro ring capacity	40 channels
Long-haul ring capacity	80 channels
Average distance between long-haul nodes	1000 km
Average distance from metro nodes to the core node	100 km
Maximum distance without regeneration	2500 km
Maximum distance without repeaters	80 km
Hands-on technician labor rate	$40 per hour
Tier 1 technician support labor rate	$70 per hour
Tier 2 engineer labor rate	$120 per hour

Total Cost of Ownership Comparison

The results of our TCO model show that in the hypothetical network considered in this example, the hiT7300 solution results in a total cost savings of 38% over the alternative metro and long-haul approach. The cumulative TCO (consisting of both CapEx and OpEx) over the five-year period of study is presented in Figure 8, and the TCO for each year of the study is presented in Figure 9.

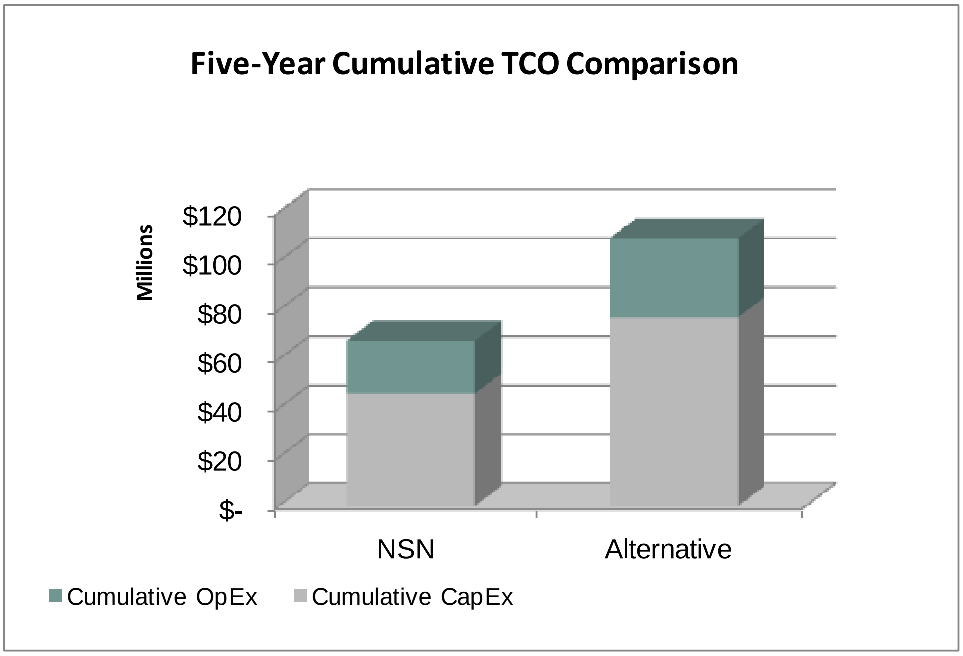

Figure 8. Five-Year Cumulative TCO

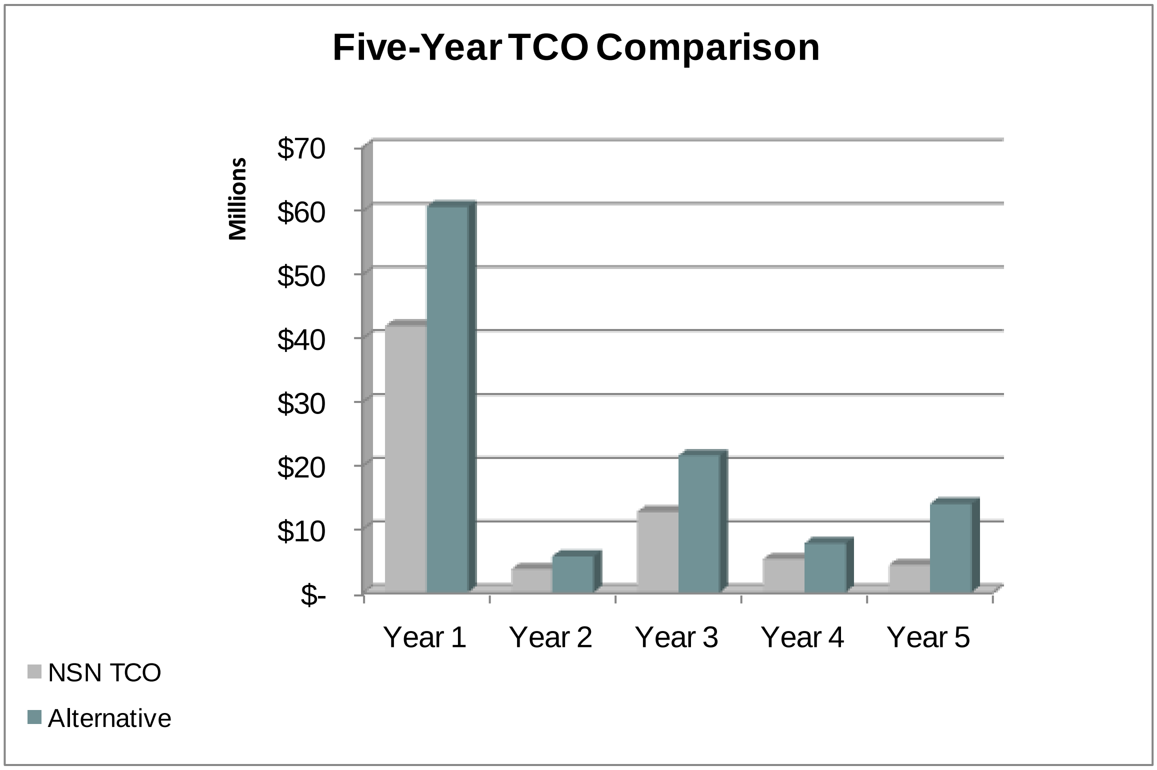

Figure 9. Five-Year TCO Comparison

CapEx Breakdown

The breakdown of five-year cumulative capital expenses for the hiT7300 architecture and the alternative architecture is presented in Figure 10. The equipment cost of the core node is 85% less expensive for the SURPASS hiT7300 network than for the alternative. The five-year hiT7300 cumulative CapEx for the core node is $5,500,000, while the alternative cumulative CapEx is $36,440,400, as shown in this example. The entire CapEx difference in the hypothetical network occurs within the core nodes. The Nokia Siemens Networks solution is less expensive than the alternative because transponders are rarely needed to regenerate signals between the metro and core networks and because only one platform is needed at the core site. This is especially true in smaller geographic areas with dense populations where metro areas are not separated by long distances, such as the eastern seaboard of the United States or Western Europe.

The configurations of the metro nodes (spur, aggregation, and hub nodes) are identical for both architectural alternatives and so is the CapEx. As such, the total cumulative CapEx advantage for the SURPASS hiT7300 solution is 40% for the entire network.

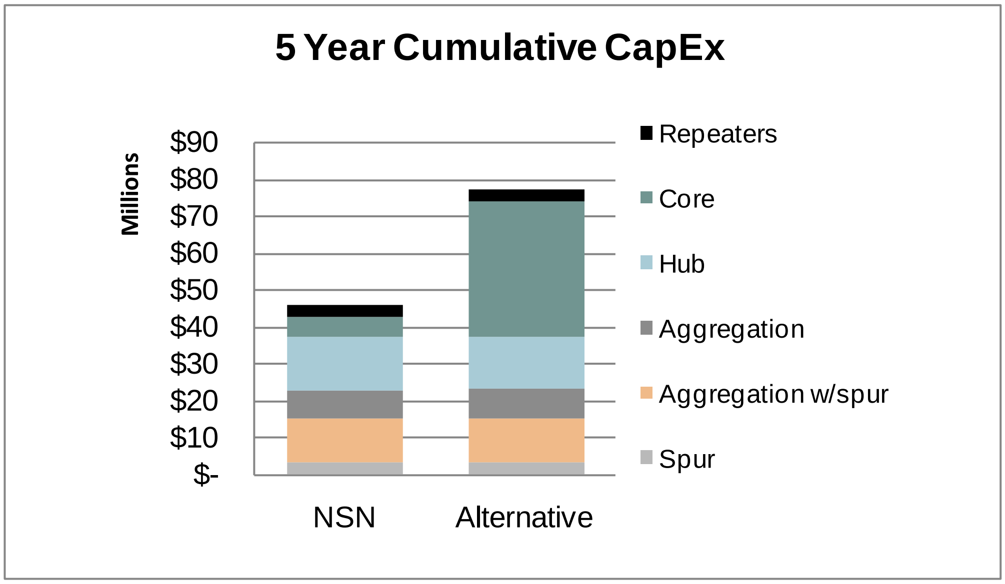

Figure 10. Five-Year Cumulative Capital Expenses (Nokia Siemens Networks and Alternative Architectures)

OpEx Breakdown

Our TCO model has forecast a five-year cumulative OpEx for the hiT7300 network of $21,535,992, while the cumulative OpEx of the alternative network is $32,225,866. This represents a total five-year OpEx savings of 33%. The breakdown of OpEx savings is presented in Figure 11, and the categories of OpEx calculated in our model are described in Table 2. The primary operational expense categories that are reduced by the SURPASS hiT7300 solution are as follows:

- Vendor service contracts (estimated to be 10% of cumulative CapEx)
- Test & Certification
- Engineering, facilities, and installation (additional equipment in the core nodes increases EF&I)
- Training (two systems require more training)
- Power, cooling, and space expenses

Operational expenses like EF&I, vendor service contracts, and environmental expenses are driven directly by the configurations of the installed equipment. Other operational expenses like network care, training, testing and certification, and network upgrades are increased by the additional complexity of managing two transport systems. For example, in the alternative network solution, training is required for both systems as opposed to a single training session for the hiT7300. All operations expenses are calculated using a proprietary OpEx model developed by Network Strategy Partners, LLC.

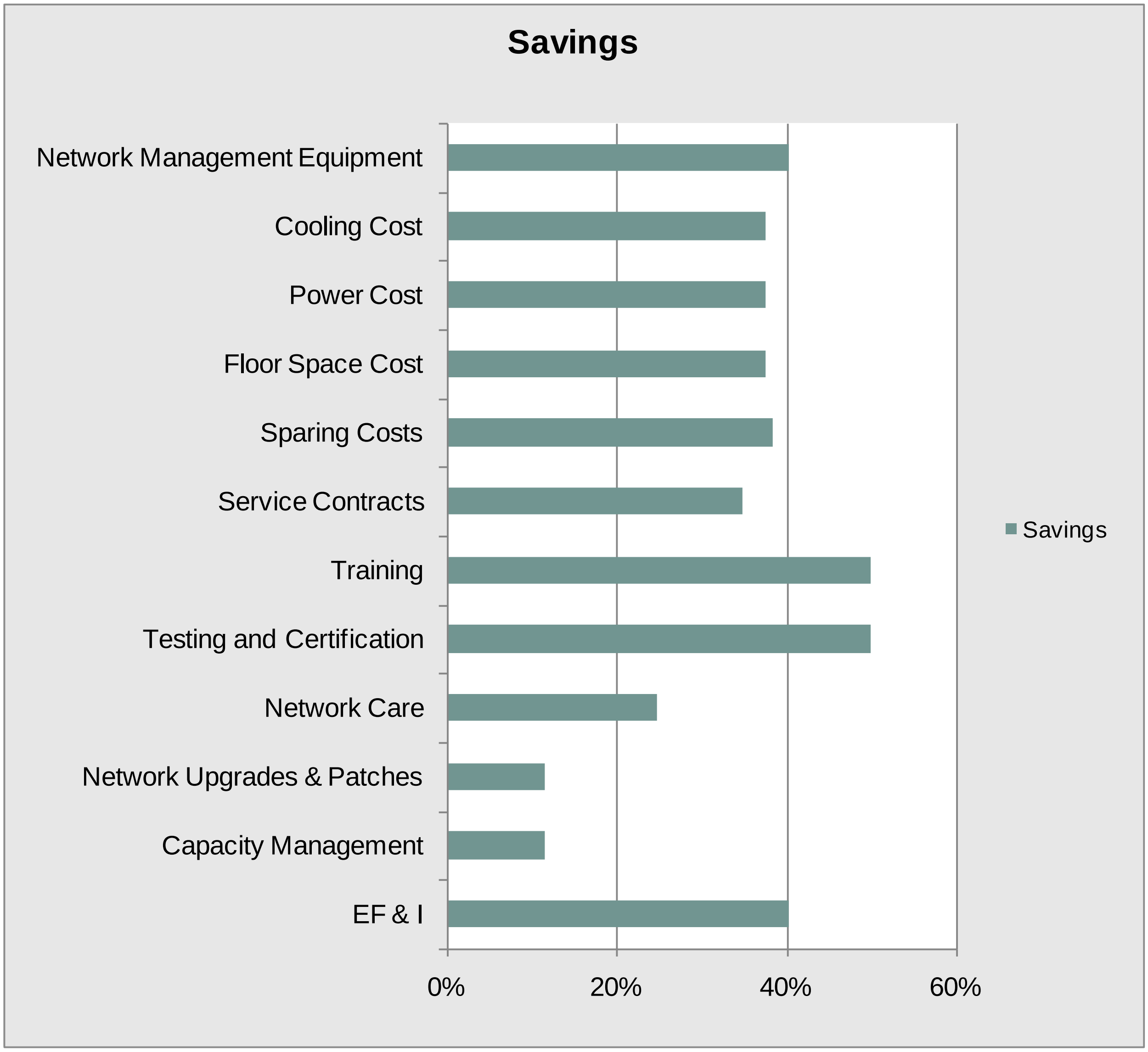

Figure 11. Five-Year Cumulative Breakdown of OpEx Savings

Table 2. OpEx Cost Components

Operations Expense	Definition
Engineering, Facilities, and Installation (EF&I)	Cost of engineering, facilities, and installation of network equipment.
Capacity Management	Engineering function of planning and provisioning additional network capacity.
Network Upgrades & Patches	Hardware and software upgrades to the network.
Network Care	Network provisioning, surveillance, monitoring, data collection, maintenance, and fault isolation.
Testing and Certification Operations	Costs associated with the testing and certification needed for all new hardware and software releases that go into the production network.
Testing and Certification Capital	Capital equipment required for the test lab.
Training	Initial training expenses, as well as ongoing training expenses.
Network Management Equipment and Software	All hardware and software required to manage the network.
Network Transport Costs	Costs associated with the transport network. The calculations of these costs are described in detail in the early section on traffic forecasting.
Service Contracts	Vendor service contracts required for ongoing support of network equipment.
Sparing Costs	Costs associated with line card spares.
Floor Space Cost	Costs associated with the floor space cost/square meter in the CO.
Power Cost	Electricity costs to power equipment.
Cooling Cost	Cost of the HVAC system to cool equipment.

Global warming and the “green” environmental movement have raised the priority of energy conservation for many service providers. The five-year cumulative environmental expenses for both networks are provided in Figure 12. The hiT7300 solution results in a 37% reduction in environmental expenses primarily due to reducing the number of transponders required at the core node as well as network elements. Power reductions are also due to eliminating the need for separate long-haul DWDM system chassis with amplifiers, DCUs, and system and timing control.

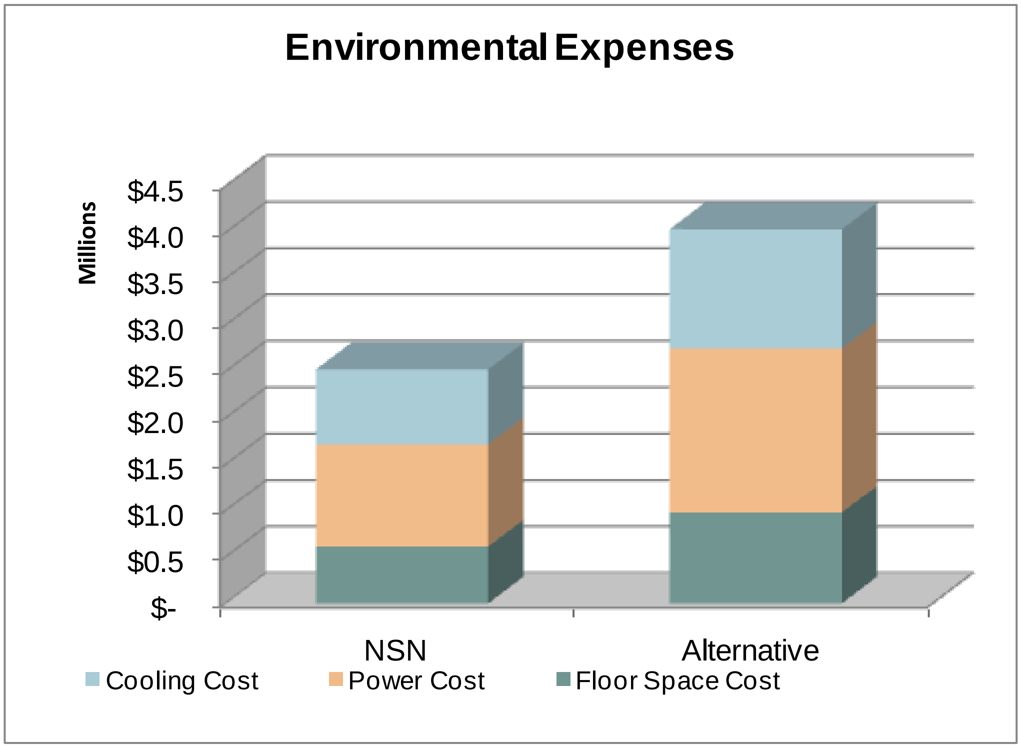

Figure 12. Five-Year Cumulative Environmental Expenses

Conclusion

Network traffic is rapidly growing and transport demand is becoming increasingly unpredictable. This is leading to a breakdown in the traditional boundaries of metro and long-haul DWDM networks. The SURPASS hiT7300 is a flexible DWDM system allowing service providers to start with small cost effective metro networks and scale to large multi-haul networks. The SURPASS hiT7300 is performance and cost optimized for metro, long-haul, and combined multi-haul networks.

This study compared two architectural alternatives: (1) the metro and long-haul networks on a common platform using the SURPASS hiT7300 and (2) separate DWDM transport systems in the metro and long-haul networks using separate products from market-leading vendors. In a region where multiple metro areas are not separated by extremely long distances, the hiT7300 system eliminates OEO conversions at the core nodes that interconnect the metro and the long-haul networks. This reduces TCO for the overall network by 38%. The savings are due primarily to eliminating the transponders and multiple systems required for OEO conversion at the core nodes and reducing the additional OpEx incurred by two systems. The CapEx and OpEx comparison was carried out with a TCO model developed by Network Strategy Partners, LLC.

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